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ETHER AND CHLOROFORM;

THEIR

DISCOVERY AND PHYSIOLOGICAL EFFECTS.

FROM THE

BOSTON MEDICAL AND SURGICAL JOURNAL; AND THE TRANSACTIONS OF
THE AMERICAN MEDICAL ASSOCIATION, VOL. I.

BY

HENRY J. BIGELOW, M.D.

ONE OF THE SURGEONS OF THE MASSACHUSETTS GENERAL HOSPITAL.

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1848.

ETHER AND CHLOROFORM:

A COMPENDIUM

OF THEIR

HISTORY, SURGICAL USE, DANGERS,

AND DISCOVERY.

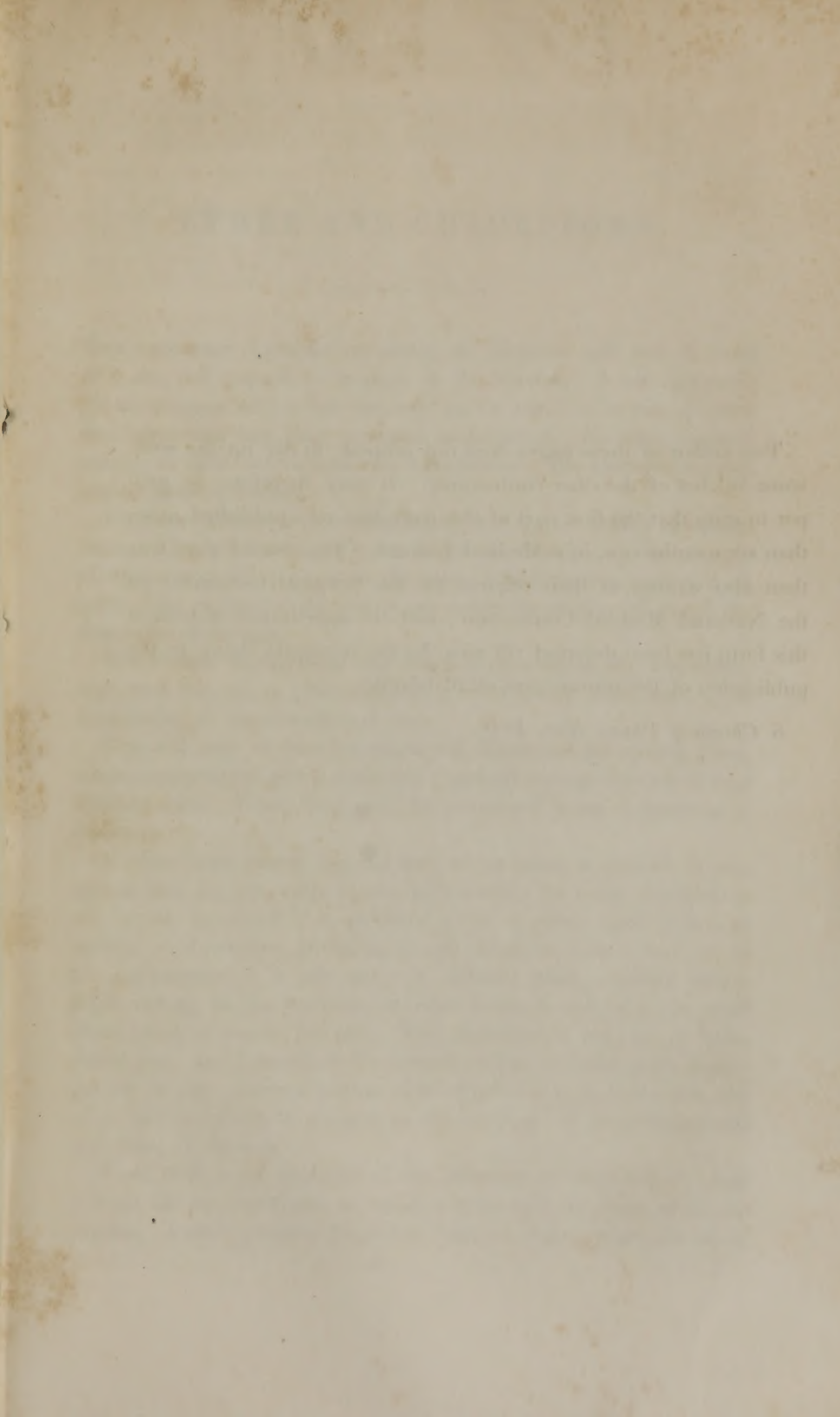
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THE author of these pages does not propose to dig up the well-worn hatchet of the ether controversy. It may, therefore, be proper to state that the first part of this pamphlet was published more than six months ago, in a Medical Journal. The second part was then also written, at their request, for the Surgical Committee of the National Medical Convention; and the appearance of both in this form has been deferred till now, by the necessary delay in the publication of the transactions of that body.

5 *Chauncy Place*, Nov. 1848.

ETHER AND CHLOROFORM.

THE astronomer Leverrier calculated the direction and rate of travel of a star, and pointed to its place in the heavens. A star appeared; yet astronomers tell us that this was not his star, that its rate of travel was other than had been predicted by Leverrier. No other appeared exactly to fulfil the astronomer's calculations. Yet Leverrier is great, and his name is familiar.

Professor Schönbein converted cotton into a new vehicle of sudden force. The belief that gun cotton might be cheaply used for purposes of offence or of defence, gave to the name of Schönbein a currency in all parts of the civilized world, and to gun cotton the position of one of the discoveries of the age.

The French experimenter has attached his name to the Daguerreotype, and this, too, is great, although a mere luxury when tested by its applicability to the necessities of man.

Few will deny to these inventions and discoveries the epithet *great*, when compared with others of the day; and yet their greatness is of very different kind. What, then, shall be considered a test of greatness in discovery?

A writer upon patents has said that an invention is entitled to protection from the law, when it materially modifies the result produced, or the means by which it is produced; that a patent right is due to novelty in a machine producing an old fabric in a new way, or to the manufacture of a new and very different fabric, resulting from a slight change in the machine; in other words, to novelty in the combined result of means and end. This distinction, if not legal, is apparently just; and I should, in like manner, call an invention great, in proportion to the combined amount of mind invested in its production, and of its intrinsic ability to minister to the supposed or real comfort and well-being of the race.

What, then, is the character of the discovery of etherization? And it is not idle nor superfluous to examine definitively the claims of this invention. I shall presently show that there are regions where the use of

multiplying experiment, while the value of the discovery would be infinitely enhanced.

To settle these important questions, many instances of insensibility were needed, which were not long in offering themselves to the tenant of a largely frequented dental establishment. Each new trial added evidence in geometrical proportion, while the absence of serious mishap encouraged hope.

Here is a second point in the discovery, and I consider a second proposition to have been now pretty well demonstrated. This was, not that ether *might* produce insensibility during the extraction of a tooth, and that the state of somnolence might be unattended with danger, but that it could always produce insensibility, and that the danger was comparatively slight.

Brief inhalation may be considered as fairly tested, and the discovery fairly demonstrated, in this rapid and multiplied experience.

Analogy, the degree of insensibility, and its superficial extent, rendered it quite probable that such insensibility would prove complete and universal. An *experimentum crucis* could alone determine such a point, nor was it long delayed.

The gentleman who had conducted these experiments determined upon submitting the new phenomena to the test of a surgical operation; and there was a certain liberality of spirit which was instrumental in introducing the discovery into the Massachusetts General Hospital. Many such pretended discoveries had failed. To be a party to such public failure, was to invite an imputation of lack of judgment; and although this novelty presented peculiar and unequivocal evidence, and possessed an intrinsic worth which need have regarded no opposition, yet a spirit of liberality and of discernment is to be recognized in the attitude of Dr. Warren, who assumed the responsibility of failure, and of the danger that might well seem possible to one who had not witnessed the previous experiments. Ether has not always met with equal consideration.

The operation of that day was incomplete in its results, for reasons to be hereafter indicated. A young man offered signs of sensibility, during and after a dissection which was not particularly painful. Some powerful drug already known, or even the imagination, might well have been suspected of agency in the phenomena.

On the ensuing day, a woman offered herself with a tumor of considerable magnitude in the right shoulder. A few minutes of the most complete and passive insensibility served for its extirpation. No imagination was here to be accused. The drooping lid, the head fallen on the

shoulder, the stolid relaxation of the mouth, suggested no overworking of the intellect, no rapt unconsciousness, nor inspired ecstasy. The phenomena were real, familiar to daily experience; they belonged to the profoundest sleep. This operation of Dr. Hayward, first showed conclusively the power of the new agent in averting the terrors of the surgical art. The casual spectator would have remarked no expression of wonder nor unusual excitement in the by-standers at the working of this miracle. Nothing to awe or startle, marred the tranquillity of the operating-room. Yet I think those present will not soon forget the conviction of those few moments, associated at this remote day with the breathless silence of the crowd, and the unwonted fumes of aromatics burned to mask the emanations from the yet mysterious agent. Cognizant of these facts, and having studied the phenomena of etherization in a number of successive experiments at the dental establishment before alluded to, I felt that there was no longer any hazard in vouching for the efficacy of ether; and on the 3d of November, I read a memoir upon the subject before the American Academy of Arts and Sciences. The case of Alice Mohan, whose limb was successfully amputated by Dr. Hayward under the new influence, occurring soon after, I incorporated this confirmatory evidence into a second paper read before the Medical Improvement Society of this city. This paper, afterwards published in this Journal, was the first upon the subject, and was that, I believe, which carried the news to the South and across the Atlantic.

It has been well said that the first attitude of the world towards a great discovery is incredulity, and then hostility; and this was well exemplified in the reception of this announcement at the South. Three weeks elapsed before any notice of the subject appeared. Then came the doubts of those sagacious and experienced philosophers who were not easily to be deceived.

In January, 1847, a New York Medical Journal announced that "the last special wonder has already arrived at the natural term of its existence. It has descended to the bottom of that great abyss which has already engulfed so many of its predecessor novelties, but which continues, alas, to gape until a humbug yet more prime shall be thrown into it."

The New Orleans Medical Journal says, in the same month, "That the leading surgeons of Boston could be captivated by such an invention as this, excites our amazement." "Why, *mesmerism*, which is repudiated by the *savans* of Boston, has done a thousand times greater wonders."

A leading medical periodical in Philadelphia, says—"We should

not consider it entitled to the least notice, but that we perceive, by a Boston Journal, that prominent members of the profession have been caught in its meshes." It was "fully persuaded that the surgeons of Philadelphia would not be seduced from the high professional path of duty, into the quagmire of quackery, by this Will o' the wisp." What the surgeons of Philadelphia have considered the "high professional path of duty," up to a very recent date, I shall soon show.

It is fair to state, that at the West, in Chicago, Buffalo, and St. Louis, the discovery received candid consideration.

The great show of dissatisfaction, emanating from those who were not contented to receive tranquilly this great discovery, and to recognize it as such, was directed against the patent right connected with its early history; but, so soon as the discovery received the confirmation of European testimony, it was providentially discovered that the patent was probably invalid, and hesitation and opposition rapidly subsided, although for some weeks the enthusiasm of periodical medical literature was tempered by the character of the reports which reached us from the other side of the Atlantic.

The article before alluded to was, I believe, the first published in the European Journals. The discovery, then, rested in Europe upon the identical evidence which introduced it to the medical community for this side of the water, and it is interesting to observe what was the attitude there assumed towards it.

Upon the arrival of the steamer of December 1st, private notices were at once forwarded to many of the eminent surgeons in London, who zealously investigated the subject. Mr. Liston, who amputated a leg, was, on the whole, successful. Yet there, as elsewhere, doubtful cases occurred. A signal failure happened at Guy's Hospital. Other cases of incomplete success contributed to place the subject upon doubtful ground. Notwithstanding these failures, the mere chance of producing insensibility to pain once demonstrated, aroused an inconceivable enthusiasm in the surgical world. The English Journal which announced the discovery, remarked, in an editorial article, "*The discovery seems to have a remarkable perfection about it; even in its first promulgation.*" "We suppose we shall hear no more of mesmerism and its absurdities as preparations for surgical operations." And of the paper alluded to and of Liston's case, it says, "it is almost impossible to discredit the statements contained in the communication referred to." A similar tone was held by other leading Journals, experiments were instituted in all the leading hospitals, and new evidence daily arrived from the provincial towns.

Information was conveyed to Paris, by a private letter, in the month

of November, 1846. The incredulity of surgeons prevented its early adoption. Velpeau "politely declined" to experiment upon it. When, however, in January, the accumulation of evidence arrived from England and America, a new interest was at once excited. Experiments, the majority of which had previously been failures, were now instituted with a Boston inhaling apparatus, which soon arrived, and before the first of February, the two great surgeons, Velpeau and Roux, averred, in the presence of the two Academies, that the discovery "was a glorious conquest for humanity." The news rapidly spread through the European cities, and over the civilized world.

Once, and only once, out of the country of its birth, did a government discountenance the discovery.

In this country, where no legal form hinders any individual from purchasing a bottle of prussic acid for his own private consumption, such interference excites comment; but, when we remember that a court adviser is quite likely to be some single philosopher who has become too wise for innovation, an error of judgment emanating from such a source is less remarkable.

In thus detailing the early narrative of the discovery I have endeavored to present the contemporaneous and accumulating evidence of experiment, in order to show how far, at each stage of its advancement, new experiments were justified, and also to exhibit in this relation, the various attitudes of those who were to be the instruments of its progress. And this is important. At various points in its history those who stood between this agent of mercy and the world, those whose duty it was to deal out to mankind this inestimable blessing, have seen fit to refuse it to the unhappy victims of surgical art, and have condemned them to severe suffering which might easily have been avoided.

It would be illiberal to impugn the motives of those who occupy this position; nor do I conceive it would be attempted by those who know the variety and complication of the secret agencies of human action. Yet a wide influence is diffused by many such, and it is impossible to calculate how far the mass of human misery may be augmented by such opinions joined to authority.

However easy it may be for an individual, or body of individuals, to promulgate what they conceive to be their convictions, yet if there is a chance of error in these convictions, and if that error tends considerably to increase the aggregate of human suffering, it will be readily conceded that the world has a right to question how far such convictions may be reasonable. Fortunately for this purpose, human reason is identical in all.

To establish how far etherization ought to be adopted by the world, let us re-examine the evidence in relation to its more obvious conclusions.

Ether was said, in one instance, to have produced insensibility. In another experiment, it made an individual unconscious of the drawing of a tooth. Twenty or more experiments were immediately instituted, with nearly the same effects and no accidents.

These were certainly novel and striking circumstances. They were calculated to arrest attention. They presented credentials which had a right to be examined. Ether had a right to be tried, candidly and fairly, unless it could be shown that its previous bad character forfeited all claim to further consideration. What, then, was its previous character? What is the *a priori* evidence respecting the danger of ether on the one hand, or its narcotic power on the other? And, first, the danger rests mainly upon the evidence of a few cases; the gentleman in Brande's Journal, the druggist's maid servant, and the young man of the Midland Medical and Surgical Journal; to which may be added the experiments of Orfila upon dogs, and Brodie upon Guinea pigs.

I put against these cases the hundreds of young men who had been for years harmlessly exhilarated by ether; I add to these well-known facts, the half hundred cases which occurred in a few weeks after the discovery; and re-affirm that, as far as danger goes, ether, before the end of 1846, had a right to be tested anew. Analogy fortifies this ground. It points to a state of dead drunkenness effected through the air tubes, as corresponding to a similar state effected through the stomach. Patients dead drunk had lost their legs without pain; others had instantaneously revived when alcohol was pumped out of their stomachs. Why should not the lungs become the recipient of the inebriating agent, and respiration be the resuscitating stomach pump? This analogy, which still holds good, was distinctly alluded to in the original article upon the subject of ether inhalation.

Many people had died when alcohol was not thus pumped out of their stomach; and might they not well die when the atmosphere of a room was surcharged with ether, and they asleep in it? If the argument from analogy proves anything, it proves that it is no more dangerous to be narcotized by inhaling ether, than to be dead drunk with alcohol. I hold, then, that at the time alluded to, the middle of November, 1846, neither analogy nor fact forbade the use of ether.

At this date, too, certain doubters shook their heads and talked of *mesmerism*. Now there was something in the previous knowledge of ether which widely separated it from such pretended agencies, whose

phenomena are opposed to our experience of the order of nature. Ether is very different from mesmerism ; and I think it must have occurred to any one who fairly investigated the subject, that it was quite possible, and even probable, that what was now affirmed of twenty cases, was, unlike mesmerism, likely to be true from all previous evidence. A gentleman well known in the professional and scientific world, hearing, on the day of the first experiments, that inhalation had produced insensibility to pain, exclaimed, as conviction flashed upon him, " I believe it ! It can be done ! Ether will do it ! " Such discrimination is not to be generally looked for ; but such a fact tends to show that previous evidence led towards ether, and not from it.

Mesmerism, in spite of the bad odor of repeated failure and deception, has not unfrequently obtained a candid hearing ; and this circumstance singularly contrasts with the philosophy that refused to give ether an impartial hearing, even after it was invested with the accumulated evidence of experience.

A hundred promiscuous cases rapidly occurred ; often in the face of hundreds of spectators, not one of whom attributed the results to deception or imagination. Many of these cases were detailed in papers published by Drs. Warren, Hayward, Peirson, Townsend, J. M. Warren, Parkman, and many others, of equal credibility. The mass of evidence swelled as it rolled onward, month after month, to every part of this country and of the civilized world ; and yet in November, 1847, more than a year after the discovery, we find it stated, that, in one of the largest hospitals in North America, ether " had not been tried at all."

For the sake of humanity, if not of science, it is to be hoped that no hospital gates are barred against ether, at this late day.

How different was the attitude of the London surgeons, who, only eight weeks after the first discovery, and with far less evidence than lay at the disposal of any one on this side of the water, hailed the American discovery with generous enthusiasm. The gentleman to whom the communication above alluded to was sent, was kind enough to return to me the replies received from some of the leading medical men. Thomas Bell writes, " I fully intend to try it the first opportunity. The cases are very satisfactory, and the whole affair most important." Liston says, December 21, " I tried the ether inhalation to-day, with perfect and satisfactory results ;" and at once writes, " It is a very great matter to be able thus to destroy sensibility to such an extent without apparently a bad result. It is a fine thing for operating surgeons, and I beg to thank you most sincerely for the early information you were so kind as to

give me of it." Of Liston's case of amputation, which is usually supposed to have carried with it extraordinary conviction, Sir James Clarke says, "The man said that he felt something was doing with his leg, but it was not pain." Yet he does not hesitate to avow, that "it is really a marvellous thing." December 17, Richard Bright, in spite of information from Guy's Hospital that "they had completely failed to produce the desired state of intoxication, apologetically writes, "However, there must have been some want of skill in this first attempt, and I can scarcely doubt that future experience will lead to better success." Lastly, Dr. Forbes adds to the American communications Liston's case, and writes, "I have sent copies of the enclosed to all the newspapers, so that I hope all the world will soon have the great news."

Here was the effect of evidence upon the scientific mind of Europe. Now it is unquestionably very respectable to doubt. The world may not question the judgment of those who suspend their judgment. Yet there are times when doubt is sophistry, and indecision culpable. Richard Bright did not delay to forward the news to Guy's Hospital, "that no time might be lost in affording so great a relief to any who might be in the unfortunate condition of being obliged to undergo a serious operation."

Ought not the motive of relieving human pain to induce the appointed officers of public charities to ask what is the nature of this anodyne, in whose behalf united nations rise to testify? Is it supposed that one of these gentlemen would lose his own arm without invoking ether? Shall none remonstrate, when those who are appointed to alleviate human suffering in administering the accumulated charities of years, virtually avow, that, having tried no experiments, and comparatively ignorant of the subject, they consider that the decision of mankind is wrong; and, acting upon this avowal, they condemn, not themselves, nor yet the reasoning community who resist their influence, but their helpless hospital patients, to the horrors of the knife!

If these consequences were limited to the sphere of a few institutions, the public would have a proportionally limited interest in the subject; but the wide-spread influence which such institutions exercise upon their own section of the country, and upon the large community of which they are the scientific centre, as well as the indirect influence they may have exercised upon governments, render it imperative at least to exhibit the actual value of the influence they choose to exert.

Equally futile were the objections to the new and patent method upon the ground of quackery and professional etiquette. Such considerations should fall before a question of this magnitude; and as to the fact, professional custom does not sanction such objections.

A few words upon the patent may not be here inappropriate. Discoverers in art tax the world for a pecuniary equivalent. In the higher atmosphere of science, which deals with abstract truth, it is not easy, nor is it usual, thus to extort a value for any application growing out of discovery. It is well that a line should be drawn between discoveries in pure science, which enlarge the sphere of the intellect and the boundaries of permanent knowledge, between such discovery, and the transitory and less disinterested labors directed to the amelioration of a narrower circle and a briefer term.

It does not harmonize with our better impulses, that a great invention in the art of relieving human suffering should be in any way conditional. I believe that nations would have emulated each other in meeting any liability generously abandoned to them as a debt of honor. Yet it should be remembered that the question of patent is very insignificant compared with the discovery itself, or the gratitude due to it. Besides which, secrets are common, and perhaps justly so, in the profession with which this discovery had an intimate connection in its early history, and a patent there is not a subject of comment.

Some of the Journals seem to have been indignant at the announcement of this patent by a regular physician. I investigated and published some of the first experiments, by the permission of those concerned in making them, and announced the patent with its extenuating circumstances, at their stipulation. That the patent was an error of judgment as well as a violation of custom, I had no doubt; I vainly endeavored, as far as my very humble influence might weigh, to prevent the final measures for procuring it. I even urged an appeal to interest; the force of which has been fully verified in this case; viz., that when the burden of sustaining his position falls on the patentee, and not upon the violator of the patent, nor upon the government who grants it, an invention may be so valuable as to be worthless to the patentee in a pecuniary point of view. In other words, the encroachment of the multitude may become too formidable for the resistance of an individual.

Finding such expostulation of no avail, and as an humble instrument in the announcement of a great discovery, I did, what I should be most ready to do every week, if by so doing, I were able to accelerate, even by a few days only, the ability of the world to relieve human suffering. Those who were most indignant at the patent, seem to have been

slowest to grant ether to their patients. A fear of "quackery" was instrumental in persuading Congress to withhold the agency of ether, when it might assuage the agony of the wounded soldier. Let us hope that such nice discriminators have no more to lay to their consciences, than a violation of professional etiquette, like that of announcing and using a patent right, by which a man is lulled to slumber while his leg is amputated.

A want of ability has been displayed in confounding the questions of ether patent and ether inhalation. Those who have declaimed against the ether patent, upon this side of the Atlantic, have found it very difficult to give a candid hearing to the separate question of ether insensibility. But it was not so abroad. In England, scientific discrimination far outweighed any discreditable feeling of prejudice or jealousy. The very unimportant question of patent was soon at rest. This error of custom or of taste was forgotten; and the united scientific world abandoned themselves to a determination of the real value of the discovery. No opportunity for experiment was lost; no evidence rejected. The whole medical community gave themselves to the work, and in a short time most honorably avowed that the discovery of etherization was not second to the discovery of their own Jenner. Let us believe that in the country of its birth, prejudice against ether inhalation will now yield to a recognition of its value.

An impartial consideration of the question—"Who was the discoverer of ether insensibility to the pain of surgical operations?" will be best attained by a previous consideration of the abstract question of discovery; reserving for its conclusion, a special application of the principles illustrated by it, to this special subject.

Why was the discovery not made before? Why did no one discern the value of the exhilarating agent which had attracted the attention of so many?

Because the human mind is fettered by long custom. It runs in the channels of routine. First diverted from its course by some little obstacle, its current swells and deepens, bearing down solid opposition that it may roll tranquilly in its distorted bed. Watch the tide of human footsteps, guided by the mind of successive generations. The pathway turns here and there to avoid some little inequality, and the old man and the child follow the winding track. Mind follows where mind has been. Few turn aside to analyze the difficulties which discouraged others. That a thing has not been, is to most men, perhaps justly, a reason why it will not be; and here is the office of philosophic incredulity which doubts the track of custom.

It is quite obvious that such incredulity may emanate from widely

differing sources. It often grows out of depth and originality of intellect ; of capacity which takes a wide and general view, discovering imperfection in mode or in material.

On the other hand, as he who is ignorant of a path may make the shortest route from point to point, so one who is not familiar with the erroneous conclusions of previous knowledge, may first trace a true result. In such a case, ignorance of error is an accidental vantage ground, which places its man considerably nearer truth, than that occupied by prejudice based upon error.

I hold that such incredulity, whether of knowledge or of ignorance, is likely to indicate a philosophic mind. It proposes to think for itself. Its experience of the world has shown it that the world may be wrong. Its experience of its own abilities has taught it to respect itself. For example, Whitney was said to form his decisions, not after the model of common opinion, but by his own nicely-balanced judgment. Perhaps in some details, humble though they be, such a mind has seen the defect of others' judgment, and has had cause to prefer its own results ; and, thus instructed, turns to a new subject, determined to win its own experience, to make its own investigation.

Such incredulity, brought to bear upon an extended system, especially in the inexact sciences, is justly viewed with suspicion ; and the reformer in politics, in the social system, or in medical science, meets no enthusiastic greeting. A little zeal, with a little error of premises or of reasoning, may then make the reformer dangerous. Here, the *experimentum crucis* cannot easily be tried, either from the number of elements in the problem, from the length of time required, or from the magnitude of interests at stake ; and the world therefore very justly maintains a degree of conservatism and immobility, in its moral, social and political relations.

In the exact physical sciences, the tenets of a reformer may be easily tested. Here the logician easily supplies himself with facts. The result of single and brief experiments made at will, can admit of little doubt. Even in the obscurer parts of medicine, where the material and immaterial influences are numerous and sometimes inappreciable every honest and logical mind must, upon points of importance, arrive at one and the same result. No danger can result from incredulity in medical science. On the contrary, in view of the errors of fact which grow out of want of time or qualification on the part of observers, or the intrinsic difficulties of the science, a healthy and vigilant skepticism of recorded facts, whether in diagnosis or in therapeutics, is of the essential methods of its advancement,

It is quite obvious that such incredulity—such distrust of recognized authority, occupies a merely negative position. It is a quality which adapts its possessor for the reception of new light, from which the act of invention may emanate. But that such act should in reality occur, certain active faculties are requisite. Positive inventive talent is required; the nature of which I shall attempt to show. But let it be remembered that there is a partial substitute for talent. It has been said that the difference between men lies more in their power of application, than in this quality. Great application, resulting from strong stimulus, will be readily allowed to bring about results, much like those of talent. At any rate, it is more nearly allied to the untiring zeal and stern energy which recognizes no obstruction to its march. It is well known that this unyielding perseverance has characterized a large proportion of inventors; it has animated them in failure, and nerved them through adversity. Of Whitney, whose cotton gin, even fifteen years ago, was said to be demonstrably worth 100,000,000 dollars to the United States, it was said, “of all my experience in the thorny profession of the law, I never saw a case of such perseverance, under such persecution. Even now, after thirty years, my head aches, to recollect his narratives of new trials, fresh disappointment and accumulated wrongs.” Fulton’s energy was marvelous. His experimental boat was completed after inconceivable difficulties in the spring of 1803, when a messenger announced that the “boat had broken in pieces and gone to the bottom.” After a momentary despondency, which till then he had never felt, and without returning to his lodging, without rest or refreshment, he labored with his own hands to raise her, during twenty-four hours incessantly. To this imprudence he attributed much of his subsequent bad health. The boat was almost entirely re-built, and was again completed in July. I take Fulton, Whitney and Arkwright as types of the mechanical inventor. They possessed, in an eminent degree, the inventive talent, but this did not predominate over determination and perseverance, as not unfrequently happens when such talent is exaggerated. Of Whitney’s power of invention, it was said, “it never ran wild; it accomplished, without exception, all that he ever asked of it, and no more. I emphasize this last expression, from having in mind the case of a man, whose inventive power appeared to be more fertile even than Whitney’s, but he had it under no control. When he had imagined and half executed one fine thing, he darted off to another; and he perfected nothing. Whitney perfected all he attempted.”

Such energy, vital to the existence of most discoveries, may grow

out of either the inventor's sense of the necessity, or his conviction of the possibility of reaching his object. And the last is another agent, mysterious to many, which is allied to the incredulity before alluded to, and which eminently characterizes the inventor's mind. It may be defined as a belief in the possibility, or certainty, of producing a result attained by the more active perception and reflection of the inventor's mind, by a series of processes which he may be, and often is, totally unable to impart. He is often, in consequence, considered as unsound or unwise; for as far as the subject in hand is concerned, the inventor is actually ahead of the world. His faculties may not be recognized as stronger, his character more forcible, his intellectual range broader, nor his knowledge of experience greater, than those of other men. Yet for the narrow point at issue, he is more competent than any other. His perceptions are stimulated and brought to a focus; and his energy is hot. He may actually become a better instrument for a special purpose, than another whose intellectual mechanism is far more complicated. Franklin, in an essay before the American Philosophical Society, gave a drawing of a water-wheel, accompanied by a demonstration, conclusive as he supposed, that such wheels could not be used to advantage in propelling steamboats. He proposed a jet from the stern. Fulton proved that among all methods proposed, the jet was the worst, and the wheel the best. Fulton was right, and not Franklin.

The power of remodelling old forms, of abbreviating method, of devising and economizing force for the passage of trodden or untrodden paths, appears to me essentially the same in most of the vocations of the human mind. Superadded to it, may be a taste or a talent for the combinations of mechanical or other force, or for the complicated details of number and of space, or for any other of the fields of science. But how often is a mind simultaneously given to various inventive fields; exhibiting its powers in various directions, and intuitively recognized and stigmatized by the world as having a genius which incapacitates it for the daily routine of life. And how many, like Newton or Franklin, who added the element of perseverance to this genius, have been distinguished for a versatility of talent, manifesting itself each year in a new field, and exhibiting in each its peculiar trait. Franklin was a reformer; Fulton a warm advocate of the principles of free trade; while Whitney, in his college compositions and in the words of his biographer, "with a spirit somewhat prophetic, anticipated the decline and overthrow of all arbitrary governments, and the substitution in their place of a purely representative system like our own."

The inventor invents or devises the means to attain his ends. He is, therefore, most likely, other things being equal, to be a discoverer, because he will best devise the instruments, material or abstract, to cross-examine nature, and discover abstract truth. Yet it often happens that an inventive talent confines itself to the exposition of mechanical truths of limited application; not demonstrating large and suggestive laws in science, but settling limited questions of expediency in art; or making combinations, as Newton did his watch, for the intellectual pleasure of it.

Such mechanical talent as that of Fulton and Whitney, and hosts of others, whose names are or are not attached to great inventions and discoveries, is not the less because it remained circumscribed by the field of mechanical force, to which it first addressed itself. The modifications of mechanical force do in fact afford an ample field to such intellect. But give opportunity to such men as Fulton, or to a thousand nameless artisans, whose talent is valued at more than gold by those who convert such knowledge into money; find some way of detecting this humble genius and give to it the opportunity for education in science and unmerchanta-ble truth, which may take the place of natural strong taste for it, and the combination of the inventive talent with the scientific knowledge, would yield the true philosopher. Newton built a watch, and, having a rare genius for arithmetic computation, discovered the law of gravitation.

It is difficult to over-estimate this talent for expedients and resources. What is American ingenuity? It is this great talent seeking a field in mechanical combinations in a country where opportunities for scientific knowledge have been hitherto comparatively rare. The elements of American ingenuity constitute the perception, the discrimination, and the resources of the American people.

The true power of originating, wherever manifested, is the combined result of a power of analysis and a power of combination; the former enabling the inventor to discover the differences between the elements of existing combinations, to detect the influence of each, and to reject the useless, while the latter perceives the relations of new elements to the problem, and invokes their agency in the new combinations. The intellectual philosopher may justly recognize in these faculties, the agency both of powerful judgment and of the imaginative quality; both brought to bear upon a range of subjects with which their possessor is familiar.

It has been conceded that this talent is peculiar; often an uncultivated gift, brought to bear upon some narrow range of material, by those whose general knowledge does not testify to their industry or opportunities, or

whose intellectual calibre and general range, does not at all comport with this local development of talent in the direction to which taste has guided it.

On the other hand, many discoveries, important to the world, owe little to this peculiar talent. They depend upon a fortunate or accidental succession of events, encircling a comparatively moderate ability ; and then the magnitude of the invention may be much out of proportion to the degree of the inventive faculty. The invention of printing, perhaps the greatest in the scale of social importance, was but a division of the Roman printing block. Gun-powder, which happens to abbreviate warfare, was an unpremeditated invention. The discovery of Jenner has been attributed—1, to his talents ; 2, to his education under Hunter ; 3, to his situation in the vale of Gloucestershire.

I would not abate a leaf of the laurel to which the discoverer has an undisputed right ; and I shall presently indicate another quality, different from the inventive talent, which ranks high in intellect, and often compensates a discoverer for this talent. I wish here to show that a discovery of great practical importance may result in part from good fortune ; from the first occupation of a ground ; from perseverance in a particular direction, or from some other adventitious circumstance ; that its magnitude and importance may be out of proportion to the character of the intellectual processes invested in it ; and that it has happened that a discovery of immense practical importance to the human race, with good fortune to aid it, has involved but an inconsiderable intellectual pang in its creation ; and in consequence, that any *a priori* reasoning upon the mode of its creation, has very little connection with what may well be a question of pure fact.

Having thus considered the intellectual qualities concerned in the invention, I pass to the progress of the invention itself, and to a consideration of its successive steps. These consist, first, of the suggestion ; and, second, of the generalization.

Perhaps the most fertile source of error in the history of invention, grows out of a misappreciation of these two stages of discovery. Yet they can be shown to differ widely, both in their character, and in the credit they deserve.

There can be no doubt that unless invention be a result of pure accident, suggestion always precedes it. It has been often distinctly recorded, in connection with the greater inventions and discoveries. Thus the vertical spindles of an overturned spinning wheel, suggested the jenny to Hargreaves. Iron rolling suggested the drawing of cotton by rollers to

Arkwright, who thus re-invented the machine (ignorant of Wyatt's previous invention) ; the valves of Fabricius, the circulation of the blood ; and so on.

In such cases the inventor or discoverer abstracted from the individual instance, some inherent element, the applicability of which to other instances, he alone saw. Hargreaves saw the value of a vertical position to spindles ; Newton, of the force which attracted the apple ; Harvey, of the idea that venous blood could run in only one direction ; and they generalized this element in re-applying it.

It does not modify the truth of this proposition, that the first suggestion or experiment should yield a new result ; that instead of a falling apple, it should be the contraction of a frog's leg, or an unpremeditated pustule on the hand of a Gloucestershire milkmaid. Such facts were still suggestions and not discoveries ; and were new only in the aspect they received from the mind whose key-note they struck ; new because attention was then first drawn to them in a new relation, and not new in their actual occurrence.

And the suggestion varies in its suggestive power, both from its own character and from that of the mind it works upon. The apple fell, and Newton alone abstracted a principle in behalf of the moon. Horace Wells says, and I believe first—" Reasoning from analogy, I was led to believe that surgical operations might be performed without pain, by the fact that an individual, when much excited from ordinary causes, may receive severe wounds without manifesting the least pain ; as, for instance, the man who is engaged in combat may have a limb severed from his body, after which he testifies that it was attended with no pain at the time. And so the man who is intoxicated with spirituous liquor, may be treated severely without his manifesting pain. * * * By these facts I was led to inquire if the same result would not follow, by the inhalation of some exhilarating gas." And it is well known that he tried the experiment, with various results, upon himself and others, in November, 1844. And yet the philosopher Seneca makes the remarkable observation—" That which presses hard upon you, and is very urgent, if you begin to withdraw yourself, will certainly pursue you and fall heavier. If, on the contrary, you stand your ground and seem resolved upon opposition, you will drive it from you. How many strokes do boxers receive on the face and whole body ! Yet a thirst of glory makes them regardless of pain."

To Seneca it suggested nothing ; but to Wells, a principle.

A suggestion derived from one or two instances, becomes an invention

only when its important element is abstracted and actually re-applied; and it will be soon seen that the abstraction itself, the supposition, the theory, without this actual re-application, amounts to nothing; and that for every actual and successful re-application of a newly-appreciated phenomenon, there have been innumerable claims from those who suspected that such re-application might be made, but did not actually make it; who mistook a single truth for a universal truth; suspicion for certainty; theory for fact.

It will be found, by reference to the histories of discoveries, that the suggestion and generalization have occurred almost invariably in the experience of one and the same individual. Though it is quite possible to conceive that while the suggestion occurred to one individual, he might transfer it for generalization to another individual, yet I am unable to find any instance in which this has occurred. On the contrary, the suspicion, the groundwork of the hypothesis, has generally stimulated and goaded the possessor, until he was able to convert it into fact. The suspicion has been then established; or, much more frequently, has not been established. It has proved erroneous; hope has not been realized, and the discovery has turned out to be no discovery. Watt, whose name is identified with the history of steam, and the soundness of whose practical views no one will dispute, speaks of "the cast of a die. For," says he, "in that light I look upon every project that has not received the sanction of repeated success."

This transfer of a suggestion, a theory, unconfirmed by fact, or relying upon one or two facts alone, is, as I have said, quite possible. It would then have the character of a ticket in a lottery which should be thus transferred, with which the recipient may draw a prize, but which is far more likely to turn up a blank.

But especially in great discoveries, the theory has not been thus made over to a second party. The perceptions of the inventor, keen upon this point, have enabled him to discern its value, and he has allowed himself no rest, no interval, in the steady prosecution of his task.

I have alluded to a second quality which contributes to discovery. The inventive talent lies at one end of the intellectual vibrations. At the other extreme is a high quality which elaborates another element; while the invention itself is the electric flash which results from the contact of the two.

Here let me do ample justice to the mind of Jenner, which I do not find to have been especially characterized, in his biography, by the inventive genius. It did possess, as an equivalent, the power of appreciat-

ing the importance of a discovery ; and it was in this power and in the perseverance that resulted from it, and indicated it, that I recognize his chief merit. Jenner comprehended that vaccination would considerably prolong the average of human existence. A breadth of view, a simultaneous consideration of many circumstances, with ability to reason justly upon them ; in short, a very clear conception of the whole subject, could alone afford the notion of importance or necessity which was to become the stimulus and proximate cause of the discovery. Few minds are capable of becoming so imbued with the importance of a merely possible result, as to permit it to divert the current of daily life. Such men are pointed at as having one idea ; their wisdom is questioned ; they are the butt of ridicule. And when the result demonstrates the accuracy of their convictions, we may fairly bow at once to their discernment and understanding, whether it detected a possibility, or comprehended a necessity which others overlooked.

At this point let us pause to make a distinction of cardinal importance. We have hitherto considered the qualities of the inventor's mind, and the successive steps of the process by which it accomplishes its end. Another element now complicates the problem. The invention is to go forth to the world ; and to establish certain relations between the world and the discoverer.

Up to this point it is quite obvious that an invention may be made, that it may grow from an original hint into a theory, which again may be confirmed beyond a doubt, by the test of repeated experiment, and yet that the whole process may be confined to the inventor's mind ; to his own cognizance. So long as he thus retains it for his own benefit or for that of a few friends, does the world stand in his debt ? Clearly not. The demonstration of the world to an inventor is a demonstration of gratitude and honor—gratitude for the donation of a great invention, honor to intellectual ability. To the latter it is conceded in the case of certain astronomical discoveries, for example, not immediately concerned in the direct welfare of mankind ; but the product of vast and recognized intellectual power.

But when a discovery becomes great, not from the character of the intellect invested in it, but from its immediate applicability to the amelioration of the condition of humanity, then the gratitude and honor conceded by the world is a mere equivalent for value received. The world will not concede this gratitude until they have received the value. They will only concede it to the source through which they receive it, and they will examine very closely the claims of those who may claim to have acted as agents in the matter.

To investigate this last position further—The world is to bestow a large reward in honor and in gratitude, but requires indisputable evidence of merit on the part of the recipient. It is prejudiced against *ex post facto* claims; because it naturally argues, first, that one who had made the invention and appreciated it, would in anticipation of this honor, grateful to all men, have published his invention when he made it; and secondly, that although such *ex post facto* claimant be a real inventor, yet he is so only in relation to himself or those with whom he has communicated; and as he either could not, or did not, make the world at large feel the full value of it, so they owe him nothing. Such is ample reason for the world's prejudice against such claims.

This suspicion of inventors who do not appear until after the world has been made to recognize a discovery, is also justified by the remarkable fact that hardly an invention of importance was ever made known, that it was not at once claimed; often simultaneously from a variety of sources. It is perfectly natural that it should be thus claimed. The world, whether in science or in art, is built up to a certain point, by the easy and wide transmission of knowledge, and upon this elevation stand a multitude of philosophers, engaged, often, in identical researches, and who will be possessed of much information upon the subject to which a discoverer first gives utterance. The world is then liable for a short time to confound their claims, to confuse the perfect with the imperfect knowledge; the incomplete result of few facts with the complete demonstration from many; the unproved with the indisputable; theory with fact. But the law of the land has left no doubt upon this point. Before ceding a patent, it first identifies a discoverer. Here is an opinion from the clear head of Judge Story. "He is the first inventor in the sense of the act, and entitled to a patent for his invention, who has first perfected and adapted the same to use; and until it is so perfected and adapted to use, it is not patentable. An imperfect and incomplete invention, resting in mere theory or in intellectual notion, or in uncertain experiments, and not actually reduced to practice, is not and cannot be patentable under our patent acts. In a race of diligence between two independent inventors, he who first reduces his invention to a fixed, positive and practical form, would seem to be entitled to a priority of right to a patent therefor."

And the actual history of discovery and invention is conclusive upon these points. The world, if it has doubted awhile, has always been right in the end. *The man who has first generalized the proposition, and first made the world allow that it was thus generalized, has been the inventor.*

About 1750 one Sultzer published an account of the peculiar taste,

arising from the contact of bits of silver and of lead with the tongue. Forty years after, Galvani brought metals in contact with a frog's leg. In each case a hint was received; Sultzer published it, but the world were not impressed with its importance. Galvani pursued the hint with numerous experiments; demonstrated that the phenomena resulted from a new modification of abstract force; compelled the world to recognize it, and was the discoverer.

The young countrywoman at Sudbury said of smallpox, I cannot take that disease, for I have had cowpox!—The Duchess of Cleveland said she had no fear about her beauty, for she had had a disorder which would prevent her from ever catching the small-pox. Were these discoverers? No. They furnished the isolated hint, and made no farther experiments. Jenner, with infinite energy and perseverance, through many successive years, in spite of ridicule, at last proved, not that cowpox might protect the system, but that it always would thus protect it, and that it was safe. He generalized the single fact, and was a discoverer.

Many experimenters raised their voice to say that they, too, had wiped up acids with a towel which had then burned like powder. Schonbein was the first to make the world allow that cotton, treated by a certain process, always would thus burn.

The Abbe Nollet suspected the identity of the electric fluid and of lightning, and experiments were made in France. Franklin, braving the ridicule of failure, flew his kite, and by this and subsequent experiments with a lightning rod, he proved that the electric fluid was thus identical.

Adams made a calculation with regard to the existence of a new planet, and could not or did not compel the world, through the astronomer royal, to listen to him. Leverrier calculated a result, compelled the world to recognize its intrinsic greatness, and the magnitude of his own mathematical power, and was the discoverer.

Jonathan Hull, the Abbe Arnal, the Earl of Stanhope, Franklin, and others, proposed to propel boats by steam. They tried it, and failed to persuade the world of the expediency or value of the method. Long after, Fulton, impressed with the immense importance of the subject, made a series of experiments and calculations, discerned the cause of previous failures, persevered through inconceivable difficulties, and in the face of ridicule he felt but did not yield to, demonstrated a proposition; not that steam, a long recognized power, might be made to move a boat, but that it could do so efficiently and profitably. He first compelled the world to recognize this great fact, and was the discoverer of this abstract truth, and the inventor of a profitable steamboat.

A hundred other instances might be cited to show that the man, to

whom the original hint occurs, is not the inventor ; nor yet he who forms a theory upon this hint ; nor even he who publishes this theory, if he does not convince other people of its truth. This last may readily occur. A man may happen upon a fortunate theory, and yet not appreciate its value ; so he gives himself no trouble to proclaim it ; or perhaps his proofs are not conclusive, and the world will not believe. Goethe knew this when he said, "many things may be discovered and made known for a long time without producing any effect on the world, or the effect may be wrought without its being observed ; wrought and yet not take hold of the multitude. This is the reason why the history of inventions is so surrounded with strange riddles."

He is the inventor who generalizes the single instance, and who makes the world concede that it is thus generalized.

Now, if there is any one point which has identified the true inventor's mind, it has been an invincible determination to compel the world to recognize the reality and value of its invention. The inventor saw it himself when other men could not, and he determined that other men should see it, and he accomplished his determination. "He," Sidney Smith says, in the *Edinburgh Review*, "is not the inventor who first *says* the thing, but he who says it so long, loud and clearly, that he compels mankind to hear him."

Recognize this point, and the question of invention is comparatively simple. Yet it is not recognized. There is no abatement of claims to previous invention. The writer of a *Life of Fulton* well says—"Those who question Mr. Fulton's claim are precisely those who have been utterly unsuccessful in their own attempts ; and it would seem that exactly in proportion as their efforts were abortive, and as they had thrown away money in fruitless experiments, their claims rose in their own estimation, and that of their partizans." And the witness, I believe before the House of Commons, probably did not overstate the matter when he gave it as his opinion, that if a man were to show that he had found a road to the moon, his neighbors would testify, that, if they had not been there themselves, they knew several individuals who were familiar with the road in question.

The above considerations have been presented with the intention and desire of exposing the authority of precedent with impartiality. I have wished that the reader should not lean to one or the other side of the ether controversy, until all these considerations were presented. It remains to show their bearing upon the gist of the evidence contained in the state-

ments which have been made in behalf of Dr. Jackson and of Dr. Morton. The considerations alluded to bear upon four principal points.

1. The character of the mind and education required for discovery.
2. The suggestion of the discovery.
3. The generalization of this suggestion.
4. Its presentation to the world.

1.—This community is familiar with the great scientific talent and attainment of Dr. Jackson. Dr. Morton has acuteness, ingenuity, zeal, and perseverance. The discovery is not of a character to have demanded extensive scientific acquirement, and it is probable that either Dr. Jackson or Dr. Morton might have made it.

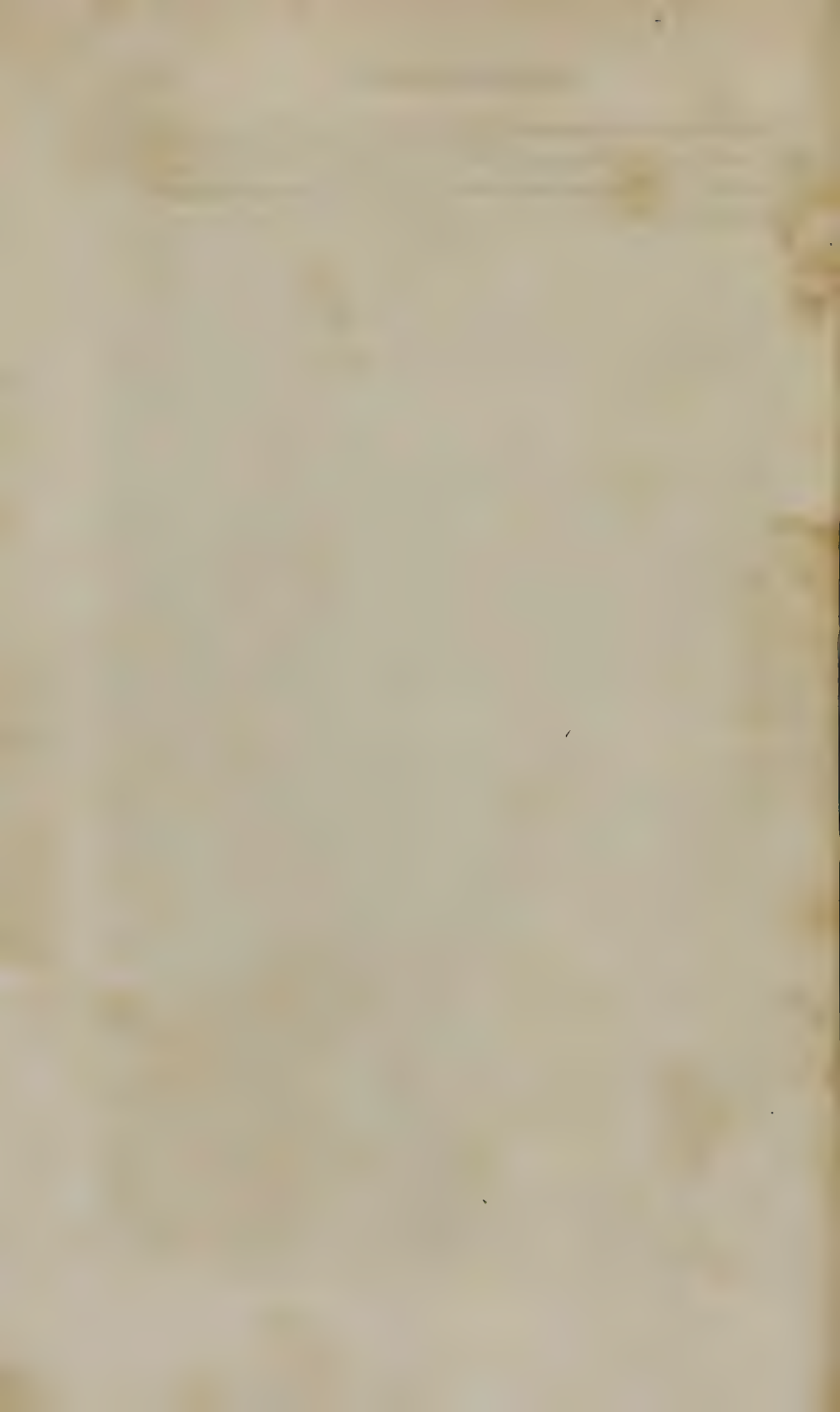
2.—The suggestion occurred to Davy, Jackson, Wells, Morton, and many others. Horace Wells seems to have conceived this hypothesis more distinctly than any other individual. So persuaded was he of its probability, that he made several experiments; and even made a journey to the Medical Class at Boston, before whom, however, he entirely failed to verify his theory. He then abandoned it, until it was confirmed by Dr. Morton. Dr. Jackson fails to prove that Dr. Morton was ignorant of the hypothesis, until he suggested it to him, because Dr. Morton shows by the evidence, that he was considering the properties of ether, at the intervals both of three months, and of three days, before his interview with Dr. Jackson.

3.—*I have shown that he who verifies the suggestion is the real discoverer. Dr. Morton, according to the evidence, did generalize this discovery. He verified the suggestion, from whatever source it emanated. He made and modified the experiments at his own discretion. He assumed the responsibility of danger. He first conclusively demonstrated of ether—1, that it would always produce insensibility to pain—2, that it was safe. These two points constitute the discovery. Dr. Morton demonstrated these points, and no one else did.*

To show that Dr. Morton was only a “nurse”—an instrument of pre-established knowledge—such knowledge must be proved to be pre-established. It is impossible for human reason to infer, upon the experiments put in evidence by Dr. Jackson, either that ether was—1, universal in its effects, or—2, that it was safe. It must, therefore, be argued that this knowledge was not pre-established—that Dr. Morton was not a mere administrator, but that he was an originator.

4. Lastly—Many may have been the real discoverers of ether insensibility to pain, and at a remote period. But if so, they have kept it to themselves; and they will be known as discoverers only to themselves.

The world has always honored that individual among such discoverers, who presented his discovery to them. Dr. Morton was, according to the evidence in print, both the prime mover and the immediate agent in the introduction of this discovery to the world.



ANÆSTHETIC AGENTS,

THEIR MODE OF EXHIBITION AND PHYSIOLOGICAL EFFECTS.

BY HENRY J. BIGELOW, M. D.

[Extracted from the *Transactions of the Am. Med. Ass.*, Vol. I.]

THERE is no difference of importance in the general character of the insensibility or other symptoms resulting from the inhalation of *ether* and *chloroform*. The latter, whose discovery in this relation the world owes to Professor Simpson, is much more potent than ether, more palatable, and less irritating to the lungs.

Chloric ether was extensively employed by Mr. Lawrence, and has been since used by other experimenters. Its effects are apparently identical with those of common ether, than which it is if anything less powerful, while its vapour may be a little less irritating. Its odour is certainly more agreeable.

Nitrous oxide was employed by Horace Wells in his experiments. It was then found to produce exhilaration out of proportion to its inebriating properties. In order to place this gas in circumstances favourable for its complete effect, it should be furnished to the lungs as freely and as pure, as ether vapour from the evaporating surface of liquid ether. It should be supplied from a large gas-holder, and not from a small gas bag; and that portion of the gas which has been deprived by the lungs of its inebriating principle, should be exhaled as waste. Thirty quarts thus inhaled by myself produced complete but brief insensibility; and on the 26th of April, I removed a breast by the aid of about twice that quantity, consumed during six minutes, and producing a most tranquil and complete insensibility. Though bulky, nitrous oxide is quite likely to prove a certain, as well as safe, and agreeable anæsthetic agent, administered in the above manner, which I have not seen alluded to. In the case mentioned, the pulse, which Dr. Townsend was good enough to note

for me, rose from 90 to 120, and continued at that point during the operation.

Aldehyde, used by Monsieur Poggiale, although it is said to be stronger than chloroform, is also conceded to be more suffocating than ether, the odour of which it has. It is probable, therefore, that ether is the less objectionable of the two agents. It produces, says Professor Simpson, much bronchial constriction and coughing.

Nitrate of ethyle, upon the same authority, is also rapid and powerful in its effects; yet produces excessive noise and fullness in the head, with subsequent headache and dizziness.

The bisulphuret of carbon, a rapid and powerful anæsthetic, has "a peculiarly offensive smell of putrid cabbage."

Benzoin. The vapour of this liquid, of rather a pleasant aromatic odour, is said to be less powerful than that of chloroform. In the hands of Mr. Snow it produced in the patient certain convulsive tremors. The four last agents are "not comparable," says Professor Simpson, "with chloroform or sulphuric ether, either in their manageableness or in their effects."

By a rough estimate of the quantity consumed in operations, chloroform is eight times as strong as ether; and a drachm of the one or an ounce of the other, is a fair allowance for inhalation at the commencement of the process. As it evaporates, the fluid may be replaced if necessary.

The absolute necessity of interposing something between the lips and the inebriating agent, when the latter, like chloroform, irritates the skin, was quite over-estimated in the case of common ether; and the public attached as false a value to the inhaling apparatus, as to the stethoscope in a kindred science. In administering ether, an inhaling apparatus is occasionally convenient. The more complicated form, in all its modifications, contains as its chief element the double valve originally suggested by Dr. Gould; and a tube furnished with it may be dilated or constricted so as to represent almost all the principal inhalers in use.

For brief and repeated inhalation, and to avoid the odour of sulphuric ether, as well as to retard its evaporation, an inhaler is convenient; but for common purposes, a bell-shaped sponge is quite efficient, and is to be turned from time to time during an expiration, to bring the gravitating ether to the top.

With the introduction of chloroform the invention of apparatus received new impetus. Its stimulant, and even vesicating properties contraindicate the direct application of this fluid to the skin.

The simplest contrivance is the best, and Simpson's folded handkerchief rolled into a cone answers well for a brief inhalation. Channing's pasteboard cone, so cheap that each patient may have a new one, lasts through an average midwifery case; a lamp-chimney, stethoscope, or other tube containing a sponge answers equally the purpose, while for the rapid and complete insensibility required for surgical purposes, and for hospital use, some more durable form of apparatus is requisite. It should comprise a mouth-piece, a receptacle for the sponge, and a diaphragm to prevent the flow of the fluid towards the mouth.

It is optional whether the vapour enter the system simultaneously through the mouth and nasal orifices, or by the mouth alone, the nostrils being closed. It has been said, that the effect is more immediate when the nasal cavities are filled with vapour; but the difference in the time of inhalation, if any, is inconsiderable.

It is a striking fact, that in many of the first experiments both in this country and abroad, vapour was inhaled from a shut cavity or sac in which the contained oxygen must have been rapidly exhausted. If there is one condition vital to the safety of inhalation, it is that an *adequate supply of oxygen should be insured to the patient.*

Inhalation should be of atmospheric air impregnated with vapour, and not of vapour alone. Air should be conducted through the medium containing the inebriating agent, and not merely to and from a closed cavity.

The production of the brief insensibility which suffices for the extraction of a tooth, is rarely accompanied with danger or with embarrassing circumstances; but the administration of ether for a length of time in a surgical operation, demands much attention. Now it is difficult for the surgeon to attend at once to a dissection, perhaps remote from the head, and at the same time to satisfy himself of the adequacy and safety of the anæsthetic state; and it is therefore not improbable that the part of etherizing, especially for a length of time and to a considerable extent, will be soon recognized as involving an entirely distinct responsibility, from that of the surgeon who performs the operation.

Let a patient be now subjected to any of the ordinary modes of inhalation, with the view of inducing for examination, some of the ordinary phenomena of etherization. It is unnecessary either to extenuate or to dissemble the symptoms which occasionally occur during the approach or continuance of the anæsthetic state. Though alarming in connection with the causes which previous experience

had assigned to them, many of them are of comparatively trifling import as a sequence of an anæsthetic agent; while, on the other hand, a few comparatively quiet indications stand at the limit of vital endurance, and give notice of real danger. The order of experience,—a few type or model cases as they occur, will perhaps afford the readiest method of exposing these phenomena.

1. A patient courageously inhales the ether;—a term intended to include the chloroform. Soon the respiration becomes more rapid; the chest heaves; the lips are blown out with the expiration, and while the patient is manifesting unequivocal signs of enjoyment, the head suddenly falls to one side, and the individual during the next two or five minutes is insensible to pain in any form. He awakes suddenly, smiles, is surprised to find the operation, if one has been performed, over; has had a pleasurable dream, and experiences no ill effects. This is etherization in its most favourable form, less frequent than the next.

2. A second patient averts his head to cough; inhales again and again coughs; declares his inability to take the ether; yet perseveres. The trachea has now become less irritable; respiration is tranquil, and insensibility of rapid access. Such cases are quite common in the practice of the dentist.

3. A third subject makes grimaces, and getting exhilarated rejects the apparatus; but is still amenable to peremptory discipline; and being directed to be quiet and to close his eyes, is soon narcotized.

4. Yet not always at once. A large and muscular man, perhaps habituated to stimulus, sometimes modifies grimace into a demonstration of resistance; closes his lips and jaw firmly, and refuses to inhale; objects to verbal and other interference; at last becomes violent, and if athletic, requires the united force of several assistants to confine him.

Here is a sufficient reason for not attempting the etherization of athletic subjects when such aid is not at hand. I believe that the best practice in such a case is to confine the patient, and to apply the ether steadily to the mouth and nose. For some seconds, perhaps many, the patient may refuse to breathe; and bystanders unaccustomed to the phenomena, exchange significant glances. But if the pulse is good there is no real danger, and at last, exhausted nature takes a deep and full inspiration, which, while it aerates the blood, is laden with the intoxicating vapour; colour returns; and the patient falls back narcotized. Violent resistance is not common.

5. It is, however, less unfrequent for the patient to vomit soon

after the appearance of the signs of etherization; and partly from the exertion, and partly from the inspiration of fresh air, he may then recover sensibility.

6. Lastly, the signs of insensibility having been manifested, the operation is begun. In a few moments the patient partially regains his consciousness, and exhibits the unequivocal appearance of suffering, which may or may not be subsequently remembered; or without being violent, is wild and uncontrollable.

It will be observed, that in all these cases, ether was administered for a comparatively short time. The result of such brief inhalation is brief narcotism, either complete or incomplete. If inhalation be arrested at this time, the period of subsequent insensibility to pain varies from one to three minutes. This short or partial insensibility is adapted to the operation of the dentist, which is usually rapid; the instrument is applied, and whatever be the demonstrations of the patient, it accomplishes its purpose. Here are no important nerves to be severed, nor vessels to be wounded. But in a dissection, such as occurs in many surgical operations, especially in one of a formidable character, it is important that the subject of the operation should not hazard his safety by being liable to sudden and convulsive movements while the knife is dealing with the tissues. If the patient thus partially revives, assistance is not unfrequently required to confine him, and it is necessary to re-administer the ether; the whole interfering materially with the tranquillity of the operation, and the comfort of those concerned; perhaps endangering the welfare of the patient.

Although many operations were performed abroad, both in England and upon the continent, and at no remote date, upon patients yet capable of movement and resistance, yet there is an obvious want of safety in operating under these circumstances. Decided preference should be bestowed upon a condition of complete and passive narcotism, provided it can be produced with equal certainty, and is equally free from serious results.

Such a condition is quite possible, and a short time suffices to induce a train of symptoms indicative of it. Let the inhalation be continued beyond the period, during which the patient exhibits the earlier signs of narcotism. The muscles will be found gradually and completely to relax under its influence; and at a later period the inspiration becomes a snore. The patient exhibits no sign of consciousness, and is, in short, profoundly narcotized.

In the symptoms hitherto detailed, two stages of the anæsthetic

state will readily be recognized; the first embracing the phenomena of partial consciousness, while the second presents the indication of total insensibility.

These two stages of anæsthesia demand separate consideration.

FIRST STAGE.—The first stage is characterized, either by the incomplete or partial character of the narcotism or by its brief duration. These phenomena suggest the notion that the blood is insufficiently impregnated with ether, or that the vapour has affected a portion only of the circulating fluid, the influence of which upon the brain is soon counteracted by the arrival in the cerebral vessels of fresh and unadulterated blood. Such theory illustrates the degree and the duration of the phenomena attending such inebriation.

The first stage requires for its induction a comparatively small proportion of the ether vapour. Insensibility, if complete is brief, and the patient revives in a period varying from one to three minutes, commonly without nausea, headache, vertigo, or other sensations of discomfort. But in certain cases, and especially when either from pulmonary irritability, or want of determination on the part of the patient, the dose has been insufficient, and its inhalation by consequence protracted through a period of six or eight minutes, a different range of symptoms is presented. The patient may be bewildered, like a man waking from a deep sleep, or uncontrollable except by moderate coercion. At this time the pulse is natural, or yet more frequently accelerated, either from exertion, or perhaps it has not regained its normal standard after the unavoidable excitement of anticipation. Though in the first stage of anæsthesia we might expect the pulse to be accelerated, yet it often deviates but little from its natural standard. Nor is the pupil especially affected in this stage. The muscular fibre is yet animated by the nervous influence, and is generally somewhat rigid; the arm resisting flexion or extension. Occasionally it exhibits the phenomena of catalepsy, retaining any position given to the limb. In rare cases I have noticed the access of clonic spasm, local or general in its invasion. When the spasm affects the glottis, it gives rise to a peculiar symptom, to be alluded to hereafter.

To the first stage of anæsthesia belong those remarkable and unanticipated physiological phenomena, which seem to unlink the intimate connection between sensation and an intellectual recognition of it; between cognizance and memory; between will and action.

A patient, thus partially etherized, is said quietly to criticise the amputation of his own leg, or resists the dentist's instruments, and to appearance suffers, and yet remembers nothing of it; or remembers, but has not felt; or, which is unpleasant and fortunately rare, has felt but could not move. Such occurrences, familiar to the early history of etherization, have been somewhat less frequent, since the subject has been better comprehended. Yet at a comparatively recent date, partial consciousness of the patient during an amputation, for example, has been regarded as a circumstance of unforeseen occurrence, and not always amenable to ready influences.

The inconveniences of partial consciousness have been alluded to; and I am now especially desirous of exposing the advantages of a state of inebriation, during which the patient lies passive and motionless, exhibiting only the phenomena of deep sleep.

SECOND STAGE.—Such is the second stage of anæsthesia, essentially characterized and identified by muscular relaxation. Let the subjects of the last mentioned experiments continue inhalation. The arm, from time to time, when raised from the side, resists. Soon, however, it becomes flexible, and at last, falls passive and motionless. The voluntary muscles are now relaxed; and it is impossible at this moment to rouse the patient. This stage requires for its induction a considerable quantity of ether vapour, which may be presented to the pulmonary surfaces either rapidly in the course of two or four minutes, or a more diluted vapour may be administered during a protracted inhalation of many minutes. In the former case, anæsthesia is of rapid access, and in its most favourable form. But in the latter, the dilute and protracted inhalation is often accompanied with the annoyances of partial anæsthesia, and it will be stated in another part of this paper that other symptoms, especially that of vomiting, are quite apt to interfere with inhalation before the inebriation has reached its second stage. The commencement of this state of narcotism, characterized by passive flexibility of the arm, suffices for any brief surgical operation, which is not likely to be impeded by the movements of returning sensibility. Yet this insensibility at its inception, though complete, is brief, and the revival of the patient often sudden.

A few additional inhalations so impregnate the system with the vapour, that revival is deferred for some minutes after the inhalation of pure air. Ether is this way cumulative in its effects. Besides this, recovery is then generally not instantaneous, but gradual

and preceded by the signs of returning consciousness, which indicate the readministration of the anæsthetic agent, and enable the surgeon thus to anticipate interruption. Protract the inhalation yet a little longer, and the inspiration becomes a snore; the pulse, which may or may not have been previously accelerated, beats slowly; while the pupil is frequently, though not invariably dilated.

Some little familiarity with these phenomena is required to enable the surgeon so to graduate inhalation as to continue the patient in this state of tranquil and deep sleep with safety.

There is no doubt that it can be done if necessary. I have frequently myself maintained insensibility nearly or quite complete for thirty minutes, and even for a longer period. While the snore is heard, the patient does not revive; yet the snore is an unnecessary symptom, and is an indication for the temporary suspension of inhalation, when a few inspirations of unadulterated air soon re-establish quiet respiration; and the patient is liable, at any moment, to swallow or give other indication of approaching consciousness. The cumulative effect of ether, before alluded to, is at this time to be borne in mind. Young subjects, too, require less than adults; so that after eight or ten minutes of insensibility in the adult, or a considerably shorter period in the young subject, the system has been impregnated with ether, and inhalation may be discontinued even before the snore is heard, without apprehension that the subject will rapidly recover. The signs of returning consciousness are the limit on one side of that degree of anæsthesia, which it is important to maintain during most surgical operations, and are indications for the reapplication of the inebriating agent, when it is desired to protract insensibility.

At the other limit of the second stage of anæsthesia, is a far more important indication of over-narcotized vitality; and here is the protection against danger. Without this safeguard, I conceive that it might well be hazardous to overshadow animal existence by this mysterious and powerful agency. The sign is *the diminution of the force and frequency of the pulse*.

In a case of the early administration of ether, at which I was present, and which has been reported, the danger from over-narcotism was quite as imminent as in any case, not fatal, I have seen since alluded to. As a bystander, on that occasion, I casually felt the pulse, and found it barely distinguishable; and though it subsequently still decreased, the means at once adopted for the restoration of the patient, proved ultimately successful. This occurrence pointed

to the pulse as an indication of the stage of narcotism; a few subsequent experiments confirmed the opinion; and I have not since hesitated to push etherization to complete insensibility, and to continue it, if necessary, during a length of time, provided the pulse remained full and strong. If it be retarded, it is curious to observe with what certainty it recovers force and frequency, after a few inspirations of pure air. It will be inferred from these remarks that the pulse is to be carefully examined during the whole anæsthetic process, and that inhalation is to be temporarily discontinued at its indication.

Briefly to recapitulate, the first insensibility, partial though it be, suffices for the dentist. It exhibits the intellect and sensibility in novel and singular relations; while muscular force may or may not be impaired. Nothing is here infallible in pulse or pupil.

The second stage is of great value, and often essential to the surgeon. It lies between the signs of returning consciousness on the one hand, and the decreasing pulse on the other. It is ultimately accompanied by snoring inspiration, and the partially dilated pupil; which, together with the period of time necessary for the cumulative effect of ether, may be considered, each, as an additional indication for the temporary suspension of inhalation.

Signs of Narcotism.—The eyes are usually closed during inhalation. Let the patient be directed to open them. If etherized, he takes no notice of the voice. Perhaps the head droops; or the hand supporting the inhaling apparatus falls. These, alone, are signs of narcotism, which may be incomplete; or, if complete, temporary in its duration. If, in such a case, the arm of the patient be raised from his side, it is quite likely to resist the effort; or when raised, remains extended; phenomena indicative of partial narcotism. If inhalation be now suspended, the patient soon regains his consciousness; either manifesting unequivocal signs of pain, or resisting interference, during the half conscious state which often precedes recovery.

It should be added, that if the patient has inspired a good dose, and for a length of time, the dentist may consider any unusual manifestation, as an indication of but partial sensibility to sudden pain; protracted inhalation may be even taken as its *priori* evidence.

One of the early and occasional consequences of inhalation is a passive cessation of the respiration, while the pulse continues good. At this moment a tooth may be painlessly extracted; but as the vapour has now temporarily ceased to gain access to the lungs, the patient may revive before the next inspiration.

Muscular relaxation; the temporary loss of muscular contractility; the passive flexibility of the arm; is the most valuable sign of complete narcotism. It is succeeded by snoring inspiration and slow pulse.

Signs of returning consciousness are, swallowing, coughing, moaning, an effort to articulate, and muscular movement.

Rapidity of access of the Anæsthetic State.—Somewhat modified by the strength and temperament of the individual, the rapidity with which the system yields, is generally in direct relation with the dose administered. The maximum dose will be again discussed under the head of dangers; but it may be here stated that many of the unfavourable symptoms owe their existence to the protracted inhalation of an inadequate dose; while after the first irritation of a large volume of vapour at once introduced into the air tubes has subsided, the patient yields tranquilly, and is much less liable to disagreeable and annoying symptoms.

Vomiting is especially connected with the long duration of the inhalation, and also with its inadequacy. So, also, is general excitement, and resistance; and probably spasm, whether of the vocal chords or of the muscular system generally.

The common imperfections of the inhaling process are, the use of too large a sponge for ether, and of too small a sponge for chloroform. The former distributes and evaporates the ether rapidly, while its interstices admit a good deal of air. The latter will not detain an adequate amount of chloroform without endangering the patient's skin. If the sponge be previously wrung out in water, its capillary attraction is increased.

ANÆSTHETIC SYMPTOMS CONSIDERED SEPARATELY.

Intellectual Phenomena.—It is said that a patient may take cognizance of the amputation of his own leg. This occurrence I have never seen, though it is far from improbable. It implies a distinct recognition of surrounding objects through special sense, at a moment of complete insensibility to pain in its severer forms. Such complete insensibility is more frequently attended with entire disability of special sense; yet sensation may be partially annulled, and the patient continue quite cognizant of the external world.

The manifestation of acute suffering, and even of well-directed resistance, may occur without the patient's subsequent remembrance of it. Here the faculty of memory is extinct.

Or memory may recall the manifestations of an operation of which it has forgotten the sensations. And it is said that cognizance and memory may be distinct, while the machinery of muscular action is deranged.

Mental excitement, hilarious or hostile, is not uncommon in an early stage of narcotism, and is materially influenced by its rapidity.

Pulmonary irritability varies with the individual.

Chloroform is less irritating to the lungs than ether, and so, perhaps, is chloric ether.

Violent cough is occasionally excited by a small quantity of vapour, while a much larger quantity may occasion none; but by a little careful graduation of the first few inspirations, the patient may be saved much unnecessary irritation. Soon pulmonary sensibility is narcotized, and the patient breathes quietly. Even habitual dyspnoea, or the paroxysm of asthma, is temporarily solaced by this agent. As the process is continued, the trachea becomes insensible to the presence of fluid, whether blood from operations near the mouth, or the increased natural secretions of the pulmonary surface.

Nausea and vomiting are not uncommon sequences or concomitants either of partial or complete anæsthesia; nor, beyond their interference with the progress of the inhalation, and with the mere comfort of the patient and of the operator, are they objectionable. They are allied to the nausea induced by other narcotic and inebriating agents, and have especial relation with the duration of the anæsthetic process.

The snoring inspiration indicates profound sleep. Varying a little in the facility of its production in different individuals, it is a constant phenomenon of a certain stage of narcotism. While it is often desirable to induce this symptom, its exhibition renders further inebriation unnecessary for the moment. It is always accompanied with muscular relaxation, and soon succeeds it. It results from the relaxation of the muscles of the palate; and in this connection it is desirable to distinguish it from another symptom, of somewhat different signification, viz:

Stertorous respiration, due to spasmodic action of the vocal chords, and allied to the spasmodic action of other muscles. It is somewhat rare in its occurrence; once heard, it will be readily recognized, and indicates a brief suspension of the inebriating process. Though of itself, it is quite unimportant, yet as the immediate cause of another symptom, it deserves further consideration. The closure of the

laryngeal aperture shuts off the supply of atmospheric air from the pulmonary tubes. The same condition results from the voluntary closure of the mouth and lips; but the last soon yields, while the spasm of the glottis gives rise, in rare cases, to a partial asphyxia, indicated by the then livid colour of the cutaneous surface. Similar lividity is often exhibited during a spasm of whooping-cough or in a hysteric fit, and is of comparatively slight importance, from the fact that when the system feels peremptorily the necessity for air, the spasm resulting from the anæsthesia relaxes, the patient breathes freely, and the blood is aerated. Two or three inspirations suffice to restore to the cheek its natural colour.

Muscular System.—The ordinary affections of the voluntary muscles have been alluded to. Organized resistance resulting from nervous excitement; tonic and clonic spasm; the cataleptic state being not unfrequent; while in one case I observed a convulsive effort of the whole system of voluntary muscles.

Other muscles are partially affected. The sphincters very rarely lose their contractility. It is well known that the uterus contracts during partial and even complete unconsciousness; a diminution of cessation of its contractile action being the rare exception and not the rule. The respiratory muscles play tranquilly during narcotism, while the heart, losing the force and frequency of its pulsations, slowly ceases to beat, in its latest and profoundest stage.

Pulse and Pupil.—Incidental excitement usually accelerates the pulse, the relative frequency of which, during the earlier stage, it is difficult from this circumstance to estimate. It does not lose either in force or frequency until the whole system is profoundly narcotized. It is then, as at other stages of the process, a most valuable indication of the condition of the nervous system, and ultimately of the limits of vital endurance.

The pupil, though commonly at first contracted, and subsequently dilated, is less to be relied on as an indication.

Prolonged insensibility is quite exceptional and rare. In the case of a young woman, of the details of which I am cognizant, such insensibility ensued upon a brief recovery of the ordinary character, and after the ordinary interval. The patient then again became insensible, apparently without cause, and slept heavily, in spite of efforts to arouse her, during an hour. The symptom which excited apprehension, was the smallness of the pulse, which at times was barely perceptible at the wrist. This patient ultimately recovered, as I believe, have all others similarly affected. The phenomena sug-

gested those occasionally presented after an amputation, when the patient awakes in acute suffering, and again spontaneously sleeps while stitches are inserted.

A few phenomena only remain to be noticed.

Convulsions have been reported, occurring at the interval of many hours after inebriation.

A gentleman of Providence informs me that he has suffered for many months from *vertigo*, *headache* and *disability for labour*, which ensued upon a dose of ether vapour.

Such cases, with others which have been detailed, must be considered as exceptional, due to peculiar and individual susceptibility, and they are also of exceeding rare occurrence.

It may be convenient to arrange etherization under several distinct heads, adapting its degree to the character of the surgical operation for which ether is to be administered.

1. *In amputations and other brief surgical operations, and in the extraction of teeth.*—In this latter case, inhalation may be discontinued a few moments after insensibility. In the former, it is better to continue it two or three minutes longer, and till muscular relaxation. For the extraction of teeth, the patient may himself retain the sponge. When the hand wavers, or falls, the mouth is carefully, but if need be, forcibly, opened, without loss of time, and the forceps are at once applied. In this way one or more teeth may be removed while the patient is in an unconscious or half conscious state, but free from pain.

2. *Protracted dissections* may be commenced a short time after insensibility; the sponge being continued to the mouth, with an occasional interval to insure the patient ample supply of oxygen. When there is snoring respiration, the sponge should be removed during the short time required to re-establish quiet inhalation. The pulse is kept in hand, and any diminution of its frequency or force, especially the former, is an indication for the admission of unadulterated atmospheric air. Forty-five minutes is a somewhat unusual duration of insensibility, and is not to be attempted by those not conversant with the process. It is important to the operator, in these cases, that the patient should be fairly narcotized, and with a little experience with a rigid attention to the above precautions, accident need not be apprehended.

It may be added that much of the pain of a dissection is not of an acute character likely to arouse the patient; so that after some time has elapsed, a state of semi-consciousness often suffices; the vapour

being then applied, either during the intervals of the operation, or as manifestations of pain or resistance may present themselves.

3. *Hare-lip*.—With this operation may be included others upon the nose and mouth, fauces and trachea. It has been presented as the type of such operations, because it embraces several particulars of interest. An operation in this region is often a dissection, and of the parts concerned in inhalation. It is, therefore, impossible to continue this process during manipulation. If, then, in such a case, the patient is to remain insensible, the surgeon has two alternatives; one of profoundly narcotizing the patient in the first instance; the other of re-administering the ether; often at an inconvenient moment, and when the operation is materially interfered with. Of these alternatives, the former seems to me the least objectionable. Another important feature in these operations, is the liability of the blood to accumulate in the trachea, which is no longer irritable or conscious of its presence. When a tracheal rale gives indication of the collection of a considerable quantity of blood or other fluid in this region, the patient should be made to lean forward, to facilitate the natural expulsive efforts of the expiration or of the cough, as consciousness returns. In general during operations upon the face and jaw, under the influence of ether, the patient should be sustained in a position inclining somewhat forwards, and care should be taken to prevent, as far as possible, by sponges or otherwise, the recession of blood into the buccal cavity. Protracted operations upon the fauces are difficult, if not impracticable, with the use of ether. On the other hand, the admission of instruments to the trachea, especially from the outside, is, without doubt, thus facilitated.

4. In *dislocation*, it is obvious that ether inhaled, can be of no avail unless continued to the relaxation of the muscles.

It is well known with what facility dislocation is reduced upon the dead subject; and it is quite probable that all recent and favourable cases in the living subject may be reduced with almost equal facility, when muscular relaxation is completely effected. This is confirmed by one or two cases of dislocated shoulder, which have fallen under my notice. I have met with no case of recent dislocated hip since the introduction of the anæsthetic agents. It would be desirable, in such a case, that an attempt should be made completely to annul muscular resistance, before efforts are directed to the replacement of the bone.

It is equally evident that the reduction of hernia can be facilitated only by muscular relaxation, and that anything approaching

to spasm would aggravate the difficulty of reduction during its access.

Lastly, ether has proved of service in abating the spasm of stricture, in lithotrity, and in the breaking up of adhesions resulting from fracture near the joints. Yet in the latter cases pain has always offered sure indication of the advisable extent of the respective operations, and in its absence, considerable discrimination is to be exercised. I have myself seen an arm refractured by an attempt to overcome the resistance of a mass of callus, after the adhesion of the articulating surfaces had yielded.

Age.—Experience shows that no especial ill effects result from the administration of ether to patients of average physical force at almost any age. Though I have operated on a child of three months, who was so far inebriated that its cries were modified into a sort of moan, yet I know of no case in which a young infant has been completely narcotized after its birth. Indeed, the facility of controlling a child of this age, together with the fact that it has neither the anticipation nor remembrance of suffering, however severe, seems to render this stage of narcotism unnecessary.

Antidotes.—It has been well said that fresh air, and in an extreme case artificial respiration is the best antidote to ether inebriation.

The symptoms of spasm, vomiting, &c., generally subside when the patient is left to himself. When the pulse is small and slow, this state of *narcotism* must not be identified with that of *syncope*. Brandy and other diffusible stimulants, appropriate remedies for syncope, belong to the class of agents which induce the anæsthetic symptoms; and it is quite probable, though evidence is yet incomplete upon this point, that the difficulty would only be aggravated by their use. Besides, the patient cannot always swallow. Cold water, dashed upon the face, or injected into the ears, undoubtedly aids in arousing the patient from the common ether narcotism. Galvanism to the precordial region has been suggested as a remedy in an extreme case; and it may be a question whether rest in the recumbent posture or active exercise, as adopted for the restoration of subjects affected with narcotism from opium, be best adapted for these cases. If any fluid is to be administered internally, analogy would suggest strong tea or coffee.

The nature of the anæsthetic state is a question of considerable interest. Perhaps the most satisfactory evidence upon this point, is that afforded by the analogy between the symptoms resulting from ether vapour in the lungs, and those of alcohol in the stomach.

Both, in small quantities, produce exhilaration. Both, in a large dose, produce the phenomena of dead drunkenness, and both, insensibility to pain. With alcohol, the state persists, while the fluid remains in the stomach; and patients have been at once aroused by the use of the stomach pump. In like manner anæsthesia continues, while ether vapour fills the lungs; respiration pumps the ether vapour from that receptacle, and gradually aerating the blood, terminates the anæsthetic state. Alcohol is found in the blood by chemical analysis; ether is equally detected in it by its peculiar odour.

Convulsions have been noticed in rare connection, both with ether and with alcohol. Finally, there is in ordinary cases, no great solicitude for the safety of a patient who is dead drunk, and experience has shown that ether narcotism is very rarely accompanied with danger.

Time does not serve for an analysis of the evidence relating to the effect of ether upon the different portions of the nervous system; nor is this evidence of a conclusive character. There may be some connection between the spasm, occasionally produced by alcohol and ether, and that induced by opium, alluded to by Todd and Bowman, resulting from polarity of the spinal cord, in cold-blooded, and even in warm-blooded animals.

Upon the same authority spasm of the glottis is among the results of irritation of the medulla oblongata. On the other hand, the medulla oblongata has been considered by Flourens, who claims this point as his discovery, to be the last stronghold from which life is driven by the anæsthetic agent. The animal then dies. Yet spasm of the glottis is not a formidable symptom.

The details of experiments in this obscure branch of physiology may be found in the papers of Flourens and of Longet, and may be compared with the intellectual phenomena elsewhere alluded to in this paper.

Dangers.—It remains only to speak of the dangers of the anæsthetic state. From this category, the symptom of asphyxia may be rejected; this being an evil easily anticipated, when due to an imperfection in the process; to the non-admission to the lungs of oxygen. Gradual and overwhelming narcotism may also be anticipated and arrested. The danger arising from the specific effects of an inebriating vapour in the pulmonary tubes may be considered, 1, as a question of experience and fact; and 2, of analogy and probability. As to the fact, I have been unable to find any fatal case

clearly resulting from the inhalation of ether, until the very recent one at *Auxerre*, apparently resulting in part from convulsions improperly treated, and in part from a neglect of the indications which the pulse affords. Of this case the details are imperfect. Deaths, like those reported by Nunn and Robb, occurring at an interval of twenty-four hours or more after the operation, may or may not have been accelerated by ether; which does not prevent, nor is to be considered responsible for, the ordinary collapse resulting in certain states of the system, after certain injuries and certain operations. The strong argument in behalf of ether is, that so few opportunities have occurred in which it could be even suspected of agency in fatal results.

With chloroform the evidence is a little different. Two somewhat remarkable cases of death, occurring during the brief administration of this agent for surgical purposes at once present themselves. The Cincinnati case and that of Mr. Meggison at Winlaton. In these cases death occurred in about five minutes from the beginning of the inhalation. In the Cincinnati case the quantity inhaled must have been considerable, from a saturated sponge in a four inch glass globe; yet in Meggison's case a drachm only was applied upon a handkerchief. It is quite possible that death resulted in the latter case, as Mr. Simpson avers, from asphyxia produced by the administration of brandy and other liquids before the patient was able to swallow. Such error would be easily avoided. Yet these instances suggest a specific cause of danger. This is the sudden impression upon the system of a powerful inebriating agent. Abundant alcoholic stimulus has often produced immediate death; and analogy would suggest that inebriating vapour in the lungs may be the equivalent of similar fluid in the stomach; and that in one or both the cases alluded to, chloroform may have produced a sudden and overwhelming shock upon the system.

Apart from the somewhat obscure case, before alluded to, there is no authentic evidence that sulphuric ether has been a cause of sudden death; and there is little doubt that this immunity from danger in its use is due in part to the comparatively moderate degree of its inebriating property, and in part to its volatility. Chloroform is much stronger than ether, while it is less volatile; so that although the vapour of a few drops may only give rise to moderate symptoms, and then escape by exhalation, that of a large quantity whose volume the lungs might easily contain, might powerfully impress the system, while the delay of its evaporation would materially

enhance its cumulative effects. Such theory suggests a consideration of practical importance. That in the use of chloroform a moderate dose should be inhaled gradually and not at once.

It is obvious, too, that the agency of heat to promote its evaporation, must increase the chance of danger. I think it may be laid down as a rule that a drachm of chloroform, at ordinary temperatures, suffices for a gradual inhalation of three minutes in the average adult. In recognizing a possible danger from an instantaneous and powerful dose on the one hand, it must not be forgotten that many of the unpleasant symptoms of the anæsthetic state are undoubtedly induced, and aggravated by protracted and futile attempts to produce insensibility, with an insufficient dose. Experience shows that after the first few minutes, and with due regard to the condition of the pulse, it is safe to increase the quantity of ether or of chloroform, until the inspired air is fully saturated, and the patient fairly narcotized.

If there is any one consideration calculated to arrest attention in the history of etherization, it is, that although the anæsthetic agents have been open to liberal use in every part of the civilized world, whether experimentally, ignorantly, or carelessly; although thousands have experienced their good effects; and although the physiologist, the ether opponent, and the coroner, have been equally ready to seize upon and to exaggerate any case of accident that might seem to fall within their range; yet it is probable that the number of cases, thus publicly suspected, have been less than ten, while the only conclusive instance of direct relation between an anæsthetic agent and death are two in number. Can antimony or opium show as clean a bill of health for the same period?

